APPENDIX F

EXISTING CONDITIONS SUMMARY AND RECOMMENDATIONS

PREPARED BY CMS COLLABORATIVE, INC.

2015

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9 November 2015

Miller Dunwiddie Architecture
123 N 3rd Street, No.104,
Minneapolis, MN 55401

Attn: Mr. Chuck Liddy

Re: Peavey Plaza Fountain Renovation – Site Visit Report and Analysis

Dear Chuck,

Per your request, CMS visited the Peavey Plaza Historical Fountain site in Minneapolis on 27 October 2015. Our goal was to provide an initial assessment of the mechanical and electrical fountain systems (structural, civil engineering, and architectural aspects are being assessed by others). Note that aspects of code adherence (e.g., ADA), safety, and so forth are not being considered in this report, since the geometry of the pools, their depth and accessibility, etc., are determined by the historical nature of the Fountain and are possibly being "grandfathered in" to the plaza landscape. These might, however, be considered in a future analysis, from an architectural and safety standpoint.

The Peavey Plaza Fountain was originally designed in 1974, and we herein describe the fountain as it presents itself today, and discuss various ways in which the fountain mechanical and electrical systems and their various sub-systems might be modernized and in general renovated.

In this regard, please note our observations, conclusions and suggestions in the report that follows.

Sincerely,

Roy Kaplan

Roy Kaplan
principal

cms fountain consultants
831.425.3743 x8

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GENERAL DISCUSSION

The Peavey Plaza Fountain, designed by landscape architect M. Paul Friedberg in the Modernist style, is a central feature at Peavey Plaza, and indeed takes up much of its geographical footprint. The plaza itself is recessed to an elevation of 10-feet below street level, and as its National Register of Historic Places Registration Form notes, the plaza is largely organized around the fountain's 140-foot x 200-foot reflecting pool. This pool is designed so that it can be drained and used for events, while the cascading portions of the fountains (see below) can still be operated - although we were told that some of the drainage fittings in the pool center were non-functional.

It has been a number of years since the fountain has been in operation, and only a few City maintenance staff members who actually operated the water feature are left to recount its various facets and idiosyncrasies. It may be that the fountain as designed had mechanical system design shortcomings from its inception. There are no original actors to ask however, and all information in this regard comes through the recollections of "old timers," who either operated the fountain or who recollect stories from long-retired "older timers."

One thing that can be stated with certainly: The Peavey Fountain is very large, its hydraulics are complicated, and the historical construction documentation is difficult to read and yields sparse information at best. Further, a number of things have been changed since the display was built. to "keep the fountain running." To use the National Register of Historic Places review verbiage, the fountain has to an extent suffered "death by a thousand patches." We have no doubt that the fountain will continue to yield additional secrets, surprises, and challenges as its proposed renovation progresses; we also have no doubt that the fountain can be restored to its original glory.

Fountain Description

An elaborate system of cascading weir pools at various elevations, along with cascading water stairs or falls, occupies the northern fountain in general, with areas of high flow more concentrated near the intersection of Nicollet Avenue and 12th Street. There are also a number of flowing runnels at the south and southeastern portion of the display.

These water effects are supplied by three fifty-HP vertical (turbine or possibly mixed flow) pumps mounted on a grate in the equipment space, which pump from the lower pool/reservoir. This is the fountains' lowest body of water, and into which all pumped water flows. The lowest pool/reservoir itself extends into the equipment space, which acts as a kind of wet-well for the pumping system. The lowest pool is at a lower elevation than the large reflecting pool, and it should be noted that there is an operational mode whereby the cascading portions of the display can be operated while the reflecting pool is drained and its structure used for special occasions (e.g., staging, farmer's Market).

- **TYPE OF PUMPS**: We are for the purposes of this description we refer to the grate mounted pumps simply as "vertical." The three 50 HP weir/cascade pumps may be of the vertical turbine, or mixed-flow designs. The two drain pumps appear to be vertical end-suction units—this is how they are shown on the historical construction documents. The exact type of pumps must ultimately be determined by inspection. Figure 1 below shows these pumps.

Figure 1

Regarding the flow through the weir pools, water from any one vertical weir pool pump may serve a number of pools with weirs at varying elevations. To keep water discharging into the higher weir pools, a complex system of deck or pool mounted, covered balancing valves which supply adjustable "throttling plugs" (as referred to by Flair Fountains) or "mud drain valves" as labeled on detail 5/SP-17 of the historical drawing set are placed in lower pools. The "throttling plugs" release water at a controlled rate. They, along with in-deck and covered balancing valves are adjusted to varying degrees of throttling to create backpressure (by restricting flow into the lower pool each plug serves), thereby creating backpressure which forces flow into the upper discharge pools. This particular use of "throttling plugs," while unique to *our* experience, seems to have been more common when the Peavey Plaza fountain was designed.

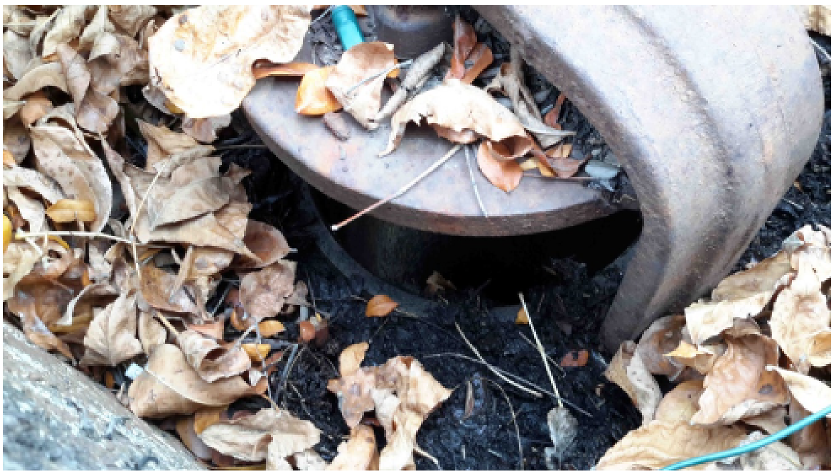

Figure 2a
("throttling plug," or "mud drain" fitting)

Figure 2b
("throttling plug," another view)

As originally designed, six of the cascading weir pools have groupings of poles ("columns") with varying heights and diameters from which water is discharged. The discharge then flows or falls into the pools below. It is noted that the poles have been removed from least one of the pools which originally had them. These poles (or at least some of them) appear to have been supplied by submersible pumps in the pool below.

It is a bit unclear as to whether the sump pumps were part of the original design, in that we were told by maintenance staff that all poles were originally supplied by the remote pumps which supplied the weir pools, cascades, and runnels. However, historic sheet SP-17 (from the original construction drawings set) shows a generic sump pump detail without identifying which fountain element or elements it supplied. Also, historic fountain plan SP-4 does suggest that a sump pump supplied the poles for each pool that has poles.

Historic sections 6 and 8/sheet SP-17 also suggest that each pole (column) containing pool had a sump pump associated that pool, which center-fed the various poles. Balancing valves in the structure were then used to divert flow away from the lower poles, and into the higher ones. However, the "center feed from below" scenario seems to have been abandoned for some unknown reason, in favor of a retro-fitted surface piping and valving system, as shown partially disassembled in figure 3a below.

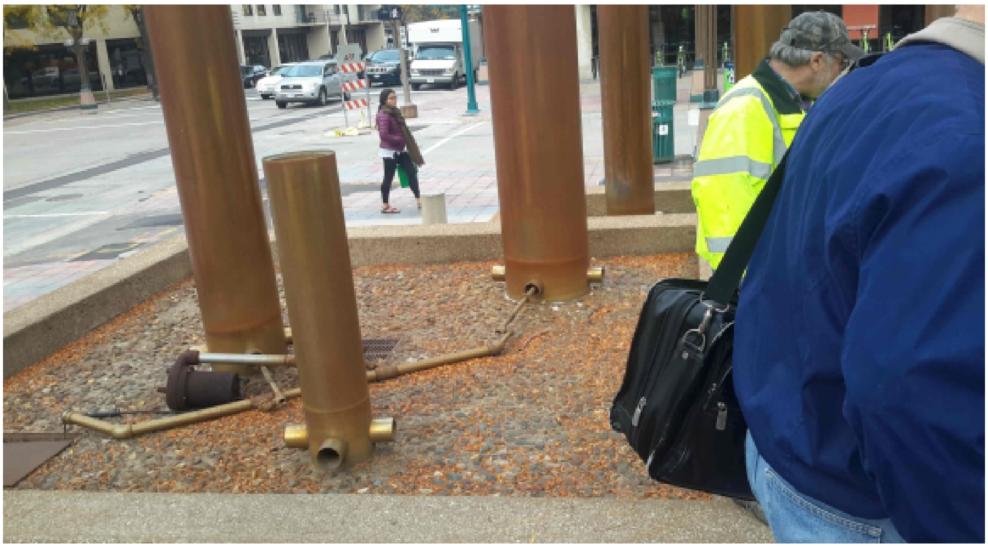

Figure 3a
(water poles, also called “columns”)

Balancing/diversion valves on the discolored stainless steel discharge piping from the sump pump is in this scenario are used to direct flow up through the poles.

The hydraulics of these poles as originally intended and as modified are somewhat of a mystery. It is not known if the original design or its modification ever produced the desired result. Each pole is actually two concentric poles, with what might be “after the fact” caulking to prevent water from flowing between the poles and out through what might be vents on the bottom (for aesthetic reasons?). Further study will be required to determine the desired aesthetic (How much water does each pole get? Does it glide down the pole or spring free?), and how the design of the poles and possibly the pumps that supply them (which may need to be bigger), interact in order to return the poles to the desired functionality.

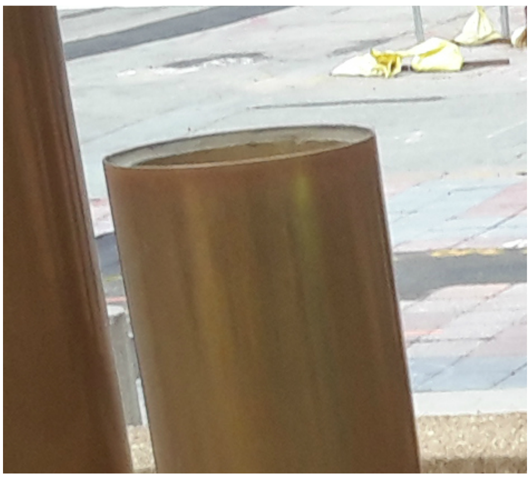

Figure 3b
(Pole element – actually two concentric poles with caulk separation)

Some pool, weir, and pole lighting seems to have existed at one time—conduit entry points are evident and the historic drawings indicate lighting, but the actual fixtures are long gone.

Two vertical drainage pumps, presumably end-suction type and float-actuated are used as ejectors to drain the lower pool as required, and apparently also pump away excess rain water. It is not clear if there is a gravity overflow system which handles rainwater; it is possible (and even probable) that these pumps form the only manner in which rainwater is discharged. If this is so, it follows that in periods of extreme rain or if there is a failure of one or both of the drainage pumps, rainwater could flood the equipment space. One maintenance person stated that this had actually happened one year, during a 500-year storm. Equipment space flooding is discussed in a subsequent section of this report.

Hydraulically, all of the visible water effects (reflecting pool, weir pools and stair cascades, poles, runnels) share water and are therefore parts of a single mechanical and electrical fountain system—i.e., served by single pumping, filtration, and electrical control systems. This strategy centralizes the maintenance point, and also removes the need for redundant systems such as filtration, control, and water treatment.

Original filtration system: The water feature utilized a single 42-inch original-equipment sand filter, which may or may not have the flow capacity to adequately filter the fountain. An assessment would need to be made by determining the time required to filter the total fountain volume (as of now unknown). "Eyeball" style wall fittings are in place, which are used to distribute filtered water around the reflecting pool. Note also that sand filters require regular "backwashing" of the media. Backwashing is a process whereby the tank is "reverse flushed." This process discharges accumulated dirt and debris and directs it to waste, but also uses up fountain water in the process, which must be replaced by municipal supplies.

The historical fountain drawings indicate that the backwash effluent is discharged into the sanitary sewer, however it is not clear from the drawings where the fountain overflow/drainage is routed. Note that by current codes all fountain discharge of chemically treated water must be routed to the sanitary sewer, by way of an "air gap" to prevent cross-contamination between the sanitary system and the fountain.

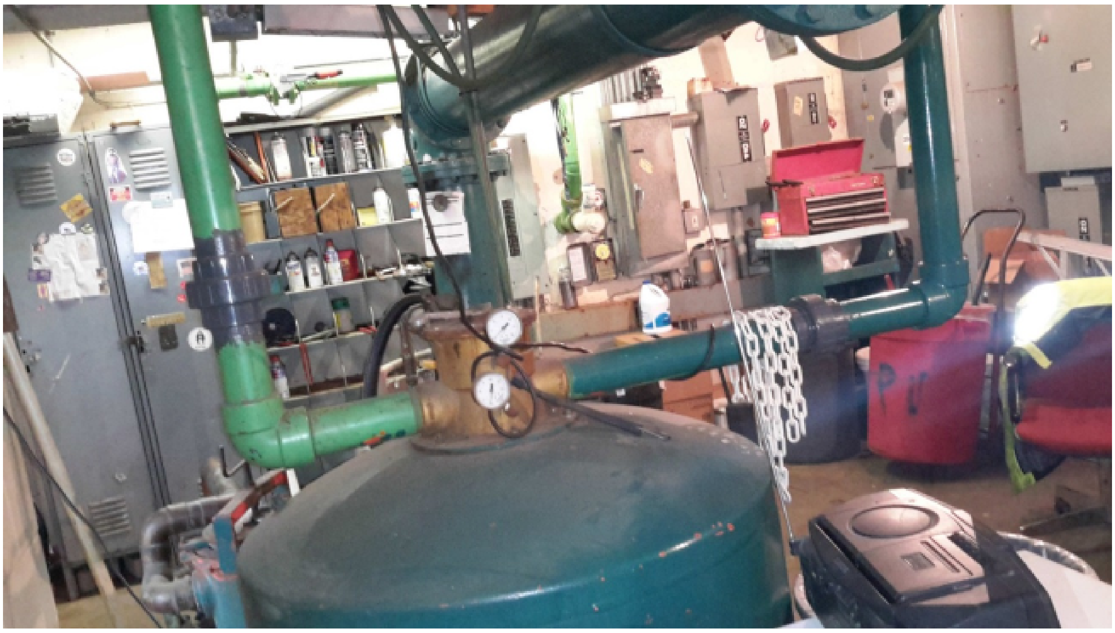

Figure 4

(Original filter tank with bronze manual backwash valve)

Water Treatment: Some sort of automated chemical water treatment system appears to have been retrofitted to the fountain at some time in its life (date unknown) in an attempt to maintain water quality. However, this treatment system seems to have been long ago abandoned in favor of manual chemical adjustments. All that remains of the treatment system is a safety eyewash and what are possibly hookups for the missing treatment gear.

COMPREHENSIVE SURVEY AND UPDATED FOUNTAIN DRAWING SET NEEDED

In order to assist us in our initial survey we were provided with photo copies of original construction drawing sheets SP-1, SP-1A, SP-2, sheets SP-4 through SP-6, and sheets SP-8 through SP-19. Sheets SP-3 and SP-7 were missing and we have no way of knowing if they were part of the fountain mechanical or electrical set. We were not provided with fountain mechanical or electrical specifications. The qualities of these drawings were and are poor, and some of the sheets are very hard to read.

Development of a Plumbing Schematic

In our opinion, one critical missing element, which we strongly feel should be commissioned, is a detailed and thorough CAD-based plumbing schematic. The schematic should be produced by a mechanical or fountain engineer, and should schematically show all pumps (each pump must receive a unique designation, e.g., display effect pump DP-1, filter pump FP-1), valves (electric and manual), filters, strainers, pipes with pipe sizes, drain plugs, throttling devices, *all* water passages at the fountain, etc. which are associated with the fountain. Piping on the schematic should also provide flow direction arrows. The schematic diagram (architects may refer to this as a *riser diagram*) is not necessarily drawn to scale--it is not a plan, but rather it is a diagram indicating how all the parts are connected to each other. The schematic diagram, much like an electrical wiring diagram, will provide a conceptual tool for understanding not only how all the parts fit together, but also how this very complicated fountain functions dynamically when the parts are working to produce the intended function.

Fountain Pool Plan and Representative Sections

In addition to a plumbing schematic, a CAD-based site and plumbing plan, with representative sections through the pools, should be drawn. As part of this survey, each pool which receives water, either via a pump or by spillover from a higher pool, is to be given a letter designation (pools “A,” “B,” and “C” are already named and shown on existing drawings). The schematic piping diagram should then show how the pumping and balancing system (using balancing valves and “throttling plugs”) connects to each named pool (hypothetical e.g.: display pump “DP-1” discharges into pool “X”; pump “DP-4” supplies the pools in “Pool Z”).

To help with this graphic representation and explanation of how the fountain functions, each pool’s weir should be marked with its elevation, which will help personnel understand the fountains various flow patterns. Each water passage, even if only a passive passage with no plumbing should be noted and its dimensions (length, width, and depth) called out for use in future piping and volume calculations.

Flow arrows on the plan should indicate how water flows from one pool’s weir to the next pool, and all piping should be labeled as to size and type (e.g., filter effluent). All piping on the plan should be provided with flow arrows.

To sum up this subsection: the goal here is to give current and future designers and contractors a conceptual framework and visual model for understanding how the fountain is put together, and as importantly, how it behaves dynamically when the water is flowing.

- These drawings can also be used as a base from which demolition drawings, new construction drawings, and as-built drawings can be produced as the renovation proceeds.

Equipment space survey

If the fountain is to be renovated, much of the renovation will likely be concentrated in the equipment space, where most of the gear will presumably be replaced and amended. We highly recommend that the survey drawing set include a comprehensive updated survey of the room (plan, elevations, and sections) showing *all* existing mechanical and electrical gear, pipe and conduit penetrations (size and centerline elevations), ventilation ducts, roof and floor elevations, beams, and wet well bottom and opening elevations, elevations, etc. This information will be required when the room is redone.

Piping System Testing

The condition of underground piping is not known at this time. We understand that a firm or contractor, who specializes in assessment of underground piping systems, leak detection, and so forth, is retained to assess the piping system's condition. Modern methods such as ground penetrating radar, videography, radio transmitters to locate piping runs, pressure testing, and so forth should be used to make the assessment. From this assessment, an accurate "as-built" drawing of buried piping should be produced, and recommendations made as to what (if any) piping runs must be repaired or replaced. This information will greatly inform the nature and extent of the renovation.

Survey of electrical Conduit Condition and Runs, and Junction Boxes

To the extent possible, a survey should be conducted and documented in CAD which shows all pool conduit penetrations, known areas of conduit routing, junction and/or pull boxes, passages meant for the routing of conduit and/or submersible conductors, and so forth.

Also, we were told that new conductors cannot be pulled through at least some of the existing conduit. We don't know if this is true for some, or all of the conduit, or in general how thorough of an investigation was conducted regarding the state of the conduit runs. We would suggest that ascertaining this information to the extent possible would be quite useful, as it may eliminate the need for at least some new conduit runs when and if the submersible pole pumps and (now missing) underwater lighting is replaced and probably re-wired.

Survey of Sump Pump Float Switch Locations and Pole Light Wiring

The original design provided float switches and junction boxes in vertical wall panels for each of the pole sump pumps and lights.

Figure 5 below provides indication of how these components were installed, presumably up until the fountain was decommissioned.

Each float switch presumably locked out the associated sump pump if the water level in the pool dropped too low and risked pump damage.

The electrical survey must document the location of each of these switches as well as the pump locations. Also note from figure five the yellow underwater chord connector housings for lighting elements.

Note from Figure 5 what appears to be an after-the-fact, make-shift stainless steel junction box, or possibly a simple (custom built) stainless steel cable pull box, with the submersible cords being connected through submergence rated couplings. Also note that the plate which fits over this cubby likely does not hold water. All penetrations in the pool and pull-box would need to be via watertight cord seals, we believe. The manner in which all these parts functioned together to produce the desired effect, and how this system might be modernized and brought back to operational status deserves further investigation. For reference, note the original (historical) installation drawing, detail 2/SP-18.

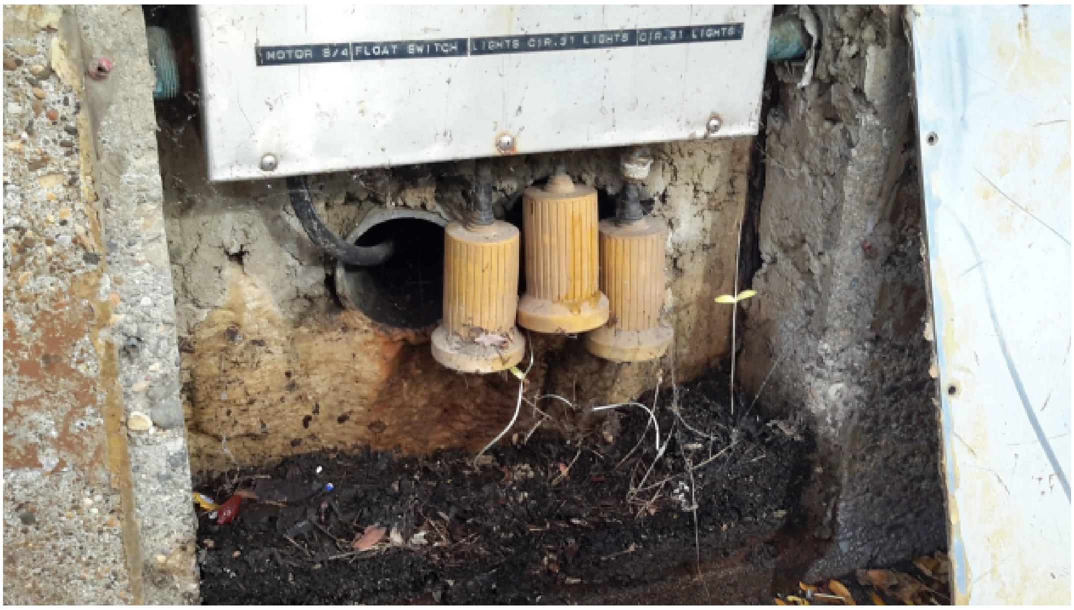

Figure 5

(Lighting connections, sump pump motor conductors, and float switch connection)

Survey of Lighting Fixtures and Locations

Underwater lighting fixtures for the weir pools and poles were included with the original design, although the actual fixtures have long since been vandalized and salvaged for parts. The aforementioned electrical survey should also indicate known locations where lighting existed, and, if possible, verification of the types and capacities of the original lighting fixtures. (We believe that the installed fixtures were 300 watt, quarts fixtures as shown by the historical drawings)

- Any and all underwater lighting fixtures over 15 VAC, and any sump pumps, must be protected by approved GFI type breakers. This is a matter of public and operating personnel safety, and also required by the national electric code (NEC). Refer to NEC article 680 for specifics.

Determination of Total Fountain Water Volume

A reasonably accurate calculation of the total fountain water volume will be necessary when sizing any new filtration system and water treatment gear (see below). Therefore, a survey of each pool that holds water when the fountain is off should be made, which will indicate the pools surface area and water depth when full. This of course includes the lowest pool into which all circulating water returns, and the portion of that pool which extends beneath the grating in the equipment space. The cubic feet of water volume from each pool should then be totalized and converted to gallons (ft^3 x 7.48). Additionally, a 5% multiplier should be added (fountain volume x 1.05) to account for an approximated additional volume of water held in the pipes.

GENERAL GOALS OF THE FOUNTAIN RENOVATION

There are a number of justifications for renovation of the Peavey Plaza Fountain--not the least of which is that this historic water feature (now a precious resource) has fallen completely into disuse and disrepair.

A new and modern design would reduce energy consumption, reduce person-hours required for maintenance through automation and more capable gear, increases equipment reliability and longevity, minimize water consumption, and so forth.

It must be stressed that this is a very complicated fountain, put together with aging, sometimes substituted, and now non-functional components, and organized according to outdated design philosophies. That being said, the fountain did operate for many years prior to this date. Questions will quickly emerge at the start of the renovation process which seek to understand just what fountain system or sub-system be modified and what new systems should be added (e.g., automated water treatment). There are no quick answers here, as many factors—not the least of which is cost—must be analyzed in terms of relative benefit, practicality, and constructability. Some desirable aspects of renovation may in the end be eliminated due excessive cost, scheduling problems, site disruption, and/or excessive disturbance of the existing fountain structure. An iterative renovation design process, coincident with costing iterations will be useful in determining what changes are ultimately "in," and what changes are "out."

This being said, below are our specific recommendations regarding renovations and embellishments of the fountain mechanical and electrical systems for fountain remediation.

AUTOMATED WATER TREATMENT SYSTEM

Along with good water filtration (see page 12) and proper circulation, another vital part of water maintenance (and maintaining an attractive and functional fountain) is a modern, automated water treatment system, typical of the type employed at commercial or municipal swimming pools.

- **Emergency Eyewash**: Any chemically based treatment system must be provided with an approved emergency eyewash assembly which is fed through a tempering flash heater designed for eyewash duty, to insure that water discharge is suitably warm.

As was noted previously, there is evidence that an automated treatment system existed at one time in the equipment space, but was removed sometimes in the past. CMS recommends installing an NSF approved, automated system which adds:

1. **Chlorine addition on demand**. This can be a liquid chlorine or a calcium hypochlorite tablet feeder system (the latter would be a "Pulsar" series chlorinator by Arch Chemical). It is important however, that the system be chlorine demand-based (ORP or PPM), so that it adds chlorine only on an as-needed basis; that the feed system is specifically designed and engineered for this purpose; and that the system is suitable for use in swimming pools.
2. **pH adjustments on demand**: This would utilize a controller routinely used in commercial swimming pools. System must use a *non-fuming* acid (non-fuming is important!). CMS typically specifies sulfuric acid, not to exceed 40%, precisely because it is non-fuming. Unlike muriatic (hydrochloric "swimming pool") acid, sulfuric acid does not produce fumes which can damage valves, pipes and electrical components. We are told that a relatively new product "Acid Magic" works well in that it is some sort of non-fuming (possibly muriatic) acid. To minimize localized piping corrosion, any acid should be introduced through a suitable "corporation stop" fitting.
3. **Conductivity (TDS) blowdown/bleed on demand**: When dissolved, mineral content reaches a setpoint as determined by the fountain operator or water treatment specialist, then an automatic "dump" valve opens and discharges water to waste. More dilute (less dissolved minerals) municipal water is than automatically added until the conductivity level falls below the dump threshold.
4. Automatic addition of a **swimming pool stain/scale inhibitor** with incoming water is also recommended. This is probably even more important than usual in the case of the Peavey fountain, since there are exposed cast-iron valves (can produce rust stains) and cast iron "throttling plugs" in some of the pools, which may stay even after the renovation. *All other things being equal, we would prefer all exposed metal parts to be bronze or stainless steel.*

We would finally note in this section that manually treated systems generally do not get proper water treatment, and therefore imply poor water quality, as overtaxed maintenance personnel do not typically have the time or impetus to keep on top of water quality. The net result over time is much scaling of architectural surfaces and damaged components.

FILTRATION SYSTEM MODERNIZATION

Good filtration using a properly sized filter is, just like for a commercial swimming pool, one of the hallmarks of proper water maintenance and along with chemical water treatment forms the first line defense against an algae bloom. A top-notch filtration system will also reduce required person-hour maintenance time. As noted previously, the original filtration system (tank is still in the equipment space) utilizes a 42-inch sand filter. We do not know the rated flow capacity of this filter as there is no labeling visible on the tank. We would note however that the piping leading into and out from the tank appears to be 3" – suggesting that maximal flow through the piping (and therefore the filter) could be approximately 140 gallons per minute (GPM). This is consistent with the typical flow through a 42-inch high-rate sand filter. The existing filter tank utilizes a top-mounted manual *filter/backwash valve* which should be abandoned in favor of a system which backwashes automatically.

- The *backwashing* refers to a filter cleaning cycle—in essence a "reverse flush" where fountain water is pumped up (backwards) through the sandbed, dislodging accumulated debris, and then the debris-ladened water is directed to waste. Backwashing can either be initiated via a manual valve or an automatic valve (we favor the latter), which backwashes automatically when filter sand bed debris loading reaches a predetermined limit.
- A typical backwash cycle normally lasts three minutes, and therefore discharges three to four minutes' worth of filter circulation to waste, at the filtration flowrate. The current filter tank would therefore dump (waste) 420 to 560 gallons of water per backwash cycle. There are typically 1 to 2 backwashes per week on average.

For the Peavey Fountain, there are two possible choices for filtration system modernization: 1) provide a new sand filter with automatic backwashing capabilities and sized based on the total water volume, or 2) use a regenerative DE based filtration system.

Sand filter based filtration with auto backwash: This is a very traditional and reliable "medium tech" method of filtration which, along with proper chemical water treatment, can achieve clear water. Installation cost is lower than comparably sized regenerative DE filter (below). Drawbacks are a relatively large footprint (bigger tank) than other methods, and that sometimes significant backwash effluent is produced, adding to overall fountain water usage. By current code, *backwash effluent must be discharged to the sanitary sewer system*. This is therefore a much less LEED friendly/water conservation oriented method than the regenerative based solution discussed below.

Regenerative Media (Diatomaceous Earth "DE" or Perlite) based filtration: This is a newer "high tech" method of filtration which, along with proper chemical water treatment, can achieve very clear water. The advantages to this method are that filtering media (DE or Perlite) regeneration, unlike a sand filter, produces no backwash effluent and therefore wastes no water. It follows that there is no additional burden on the sanitary sewer. Also, these filters tend to provide much higher filtration flow rates at any given tank diameter—important in a mechanical room short on space—and they filter significantly smaller particles than a sand filter. Drawbacks: The regenerative Media filters can cost upwards of 50% more than a sand filtration system of similar capacity. Also, while taking up a smaller footprint, these filters tend to require more vertical clearance than their sand filter counterparts.

Filtration system flowrate and turnover rate: The size of the existing filter notwithstanding, we recommend that the new filter's turnover rate—defined as the time it takes to filter the whole volume of fountain water once—be approximately 4 hours or less. This relationship then determines sizing requirement for the filter and its filter pump. A residential swimming pool would typically have an 8-hour turnover late (slower filtration), but we feel that an adequately or even generously sized filter will serve the Peavey Fountain well and go a long way towards maintaining good water quality .

A note concerning cartridge filters: These are larger versions of what one finds in a backyard spa. While they are very inexpensive and take up a relatively small footprint, they are very high maintenance in that the filtering cartridges must be frequently removed and cleaned—sometimes requiring a remote acid wash by a local swimming pool service company. *CMS strongly recommends against utilizing cartridge filters.* No maintenance department we know of is happy to have inherited a cartridge filtration based system. What usually happens is that due to a shortage of person power, the filter cartridges are not properly cleaned, flow through them diminishes, and water quality suffers greatly as a result.

<u>Filter pump control</u>

As part of the new filtration system, we recommend that the new filter pump motor be variable frequency drive (VFD) rated, and operated by a VFD.

Energy usage can then be minimized by using feedback from a magnetic flow transmitter, properly installed on the filter effluent or pump suction line, which feeds real-time flowrate information back to the fountain control system. The control system is then configured (using a PI or PID loop control scenario) to monitor the actual flowrate as it slows due to debris buildup, and make speed adjustments so as maintain a constant filter flowrate between backwash or tank regeneration cycles - the pump speeds up as resistance to flow increases, just enough to maintain the design filtration rate.

The pump therefore does not have to be oversized, and uses only the amount of energy required to deliver the proper flow at any level of debris loading.

- Especially on larger filters, *this strategy can save many thousands of dollars per year in energy costs*, while reducing the installation's carbon footprint. Filtering efficiency is also maximized as the design (clean filter tank) flowrate is maintained between backwash or regeneration cycles, even as dirt builds up in the tank.

One regenerative (DE) based filter manufacturer, Filtrex, actually supplies a pre-programmed VFD as part of their overall filtration system, for the efficiency and energy consumption related factors noted above.

WATER CIRCULATION PATTERNS

Good water circulation is vital for the maintenance of water sanitation and clarity. In essence, filtered and chemically treated water must be circulated to all parts of the display—and this is especially important in a water feature of the size and scale of the Peavey Plaza Fountain. To insure this, a system of filter "eyeball" type wall fittings was installed as part of the original design to guarantee circulation to the remote display regions. The operational status of these fittings must be verified during any fountain redesign/renovation, and in general, it must be insured that all parts of the display are properly treated and filtered.

PLAZA, LAWN, AND POSSIBLY PLANTER DRAINAGE INTO FOUNTAIN

We were told on site that area drains in the plaza and lawn empty into the fountain, which is then used as a collection basin for water which is then discharged to what probably is the storm sewer.

- Draining fountain water to the storm system was often allowed in the 1970s, however current codes require discharge of treated fountain water or backwash effluent to the sanitary system.
- Any connection to the sanitary sewer must be run through an "air gap" in order to prevent cross-contamination of the fountain from the sanitary system.

Using the fountain to capture plaza and lawn runoff is ill-advised for two reasons:

1. Water from the lawn or planter areas is likely to be nutrient rich. This will put an additional burden on the water treatment and filtration systems, and may at some point be responsible for an algae infestation. At the very least this strategy will increase chemical usage.
2. The current fountain overflow system utilizes vertical drainage pumps (we believe of the end-suction type) in the equipment space to discharge fountain water to waste (again, probably to the storm system as part of the original design. In periods of heavy rain, this added inflow of water, greater than that which would occur if only the fountain surface area accumulated excess water, could be the "straw that broke the camel's back" – in this case providing enough extra water to overwhelm the capacity of the sump pumps (especially if one of them is malfunctioning), and causing the equipment space to flood. Our understanding is that the equipment space flooded at least once, albeit in a 500 year storm. Nonetheless, we wonder if the room would have flooded if area, lawn, and possibly planter drains were not adding to the burden of the drainage pump systems. Equipment space flooding is discussed in more detail below.

CMS recommends that if technically feasible, a scenario be implemented which does not rely on the fountain as a central drainage point for site runoff.

DISPLAY EFFECT PUMP CONTROL

The display effect pumps consist of the three large vertical pumps which supply the various weir pools and cascades, and the submersible pumps which supply the water poles.

Vertical Display Effect Pumps

Again, these supply the weir and cascading stair pools. While these units are probably 40 years old, the basic pumps (as opposed to their motors) may still be operable or at least re-buildable. They must be inspected by an independent, reputable, and unbiased pump mechanic or engineer in order to make this determination. A component of this determination would relate to the pump's screening requirements and whether or not the original system provided adequate screening.

Pump Motors: Even if the pumps are salvageable, we highly recommend that their motors each be replaced by ones capable of being operated without damage by a *variable frequency drive* (VFD). Older motor designs do not have compatible winding insulation and may be damaged when coupled by a VFD.

Advantages: "Drives" or VFDs as they're referred to are capable of accepting a signal which determines how fast the pump will spin, and therefore can be used to vary pump output by a modern control system (more on this later). It must be stressed that old style motors (motors that were manufactured before the advent of drives) will be degraded in short order if connected to a drive. However, VFD rated drives are now quite common and are used extensively by the water feature and other industries.

The new VFDs would replace the existing auto-transformer type reduced voltage motor starters which supply power to the large effect pumps.

The use of drives maximize energy efficiency, and this could save thousands of dollars per year at Peavey, given that the combined pump horsepower of all the Peavey Fountain pumps probably approaches 175 HP. Essentially, pump output is controlled by slowing the pump, while controlling output the "old fashioned way" involved burning excess pump HP across a partially closed valve, because the pump would always run at 100% speed. A pump that can be operated at 90% speed to achieve a given flow will only use about 73% of the energy used by a pump operated at 100% speed with output being controlled by a throttling valve. The energy and cost savings will add up, and the carbon footprint of the installation will be diminished.

Finally, drives act like "reduced voltage motor starters" in that the limit the inrush current when the motor starts—inrush which if produced by large motors causes voltage drop across the surrounding local grid (lights dim momentarily, and computers can be bothered as well).

Submersible Pole Pumps

The existing pole pumps appear to be in bad repair—rusted with cracking electrical cords emerging from their motors. We suggest replacing these with new pumps of the same flow and pressure capacities. These capacities will have to be calculated (flowrate and pressure requirements) or reverse engineered if pump documentation cannot be ascertained.

Pumps should be equipped with VFD rated motors, for the same reasons stated above concerning the big vertical effect pumps. Energy consumption is reduced, and output can be precisely controlled by a to-be-installed modern control system.

Pole Wind Control System

Fountains with vertical elements (e.g., spray jets, waterfalls, and in this case “poles”) often have “wind control systems” which lower or terminate flow during periods of moderate to high winds.

- A *single stage* wind control system will simply stop the effect if the wind exceeds an operator adjustable setpoint and keep the effect off until wind speed falls below the setpoint for a defined period of time.
- A *dual stage* wind control system, as its name implies, provides two operator adjustable setpoints: If the wind exceeds the lower operator adjustable setpoint (moderate wind), the output of the pump(s) will be reduced to an operator programmable value—e.g., 1/3 normal spray jet height--and keep the effect at reduced capacity until wind speed falls below the low stage setpoint for a defined period of time. If the wind then exceeds the higher operator adjustable setpoint (high winds), the pump or pumps will be shut off until wind speed falls below the low stage setpoint for a defined period of time. During low stage wind control (moderate wind), one or more VFDs are slowed down to reduce pump output, and this is the most energy efficient way to produce low stage wind control.

Type of wind controller: Current designs by CMS utilize an ultrasonic type wind sensor/transmitter, which transmits wind speed and directional data back to the main fountain control system, typically via 4-20 milliamperes signals which are proportionate to speed or direction. The fountain’s microprocessor based system then produces the wind control functionality as described above, based on real time data from the wind speed sensor/transmitter. A single stage scenario for the poles may be most advantageous here.

Use of ultrasonic transmitters is desirable because the architectural footprints are low. They are small and have no moving parts, and unlike old “weather vane” type units, ultrasonic units easily transmit directional data. While use of the directional signal is rare, there are instances where some elements are well served by directional control—if it is acceptable for the effect to continue operation if the wind blows one way, but not in the other.

UNDERWATER LIGHTING

Underwater lighting was part of the original fountain design, as shown in plan on historical construction drawing sheet SP-5. As the original fountain utilized underwater lighting, CMS believes this lighting should be renewed as part of the renovation.

When supplying new fixtures, DMX controlled/LED-based underwater lamps should be utilized, as they can minimize lighting related consumption by 80% while providing extremely long lamp life.

We do not recommend employing colored lighting routinely at the Peavey Fountain during periods of normal usage (the original design utilized white quarts lamps). However, LED fixtures can be provided with programmable, color changing capabilities as well as the ability to produce white light. While not true to the spirit of the original fountain lighting, colored lighting shows could run for special occasions, e.g., a red and green motif for Christmas, blue and white for Hanukah, pink for Breast Cancer Awareness Month, green for St. Patrick's Day, and so forth.

Finally, note that by code any AC lights over 15-volts must be protected by a GFCI style circuit breaker.

INSTALLATION OF A CUSTOMIZED, MODERN CONTROL SYSTEM

It appears that there is no control system available to operate and monitor the fountain. In general, a control system minimally would:

- Schedule operation of the weir and pole pumps.
- Monitor run/off status of each pump.
- Allow for remote scheduling of pump operation if required.
- Possible use of smartphone to start or stop pumps.
- Set pump speeds in various operating modes (e.g., low stage wind control).
- Automatically add fresh water to make up for losses due to, for instance, evaporation, misting, conductivity (TDS) blowdown, and filter backwashing cycles for systems utilizing sand filters.
- Monitor water level of the lowest pool via conductivity based "probes," a pressure based level sensor/transmitter, or an ultrasonic level sensor/transmitter, and stop the fountain if lower pool levels fall low enough to potentially damage the pumps.
- Monitor any flooding which may be occurring in the equipment space, and take steps to mitigate this flooding if possible. Also, alarm notification would be sent to operating personnel.
- Stop the pumps if suction screens clog with debris.
- Operate pump-down drain mode for lowest pool if initiated.
- Possibly monitor water treatment parameters (pH, sanitizer level, etc.).
- Connect with the internet so that fountain functions can be remotely monitored.
- Communicate critical alarms via dialers, emails, or texts to fountain operators.
- And so forth.

As stated above, no obvious control system of any sort was visible during our inspection--although there may have been one at some point been in the fountain's history, now long vanished in the past. From what we observed, the fountain was operated only manually in its later stages (switch the pumps on in the morning, then come back and turn them off in the evening, etc.).

We strongly suggest that a modern, fully automated control system be designed, programmed, and commissioned by a control system integrator—ideally an integrator with significant experience in the water feature industry (they do exist).

The new control system will likely be PLC (Programmable Logic Controller) and HMI (Human Machine Interface/touchscreen) based. As noted above, the modern control system will provide internet based communication, to be used by remote operators and programmers if need be. This mode of control is very common on the factory floor, routinely operates industrial processes, and is now widely employed in the fountain industry. The new control system will make fountain operation much simpler and hopefully prevent any problems which might otherwise develop from a largely unmonitored system.

FOUNTAIN OVERFLOW AND EQUIPMENT SPACE DRAINAGE SYSTEM

Most likely as a consequence of Peavey being a "sunken plaza," well below the storm and possibly sanitary sewer lines, the fountain utilizes two vertical wet-well pumps, probably end-suction type, for pumped (forced) fountain overflow and equipment space drainage functionality. As noted previously, the fountain's lowest pool extends as a sort of a wet-well into the equipment space. There is then a floor level grate in the equipment space, installed over the lower pool region below, within the equipment space. The two vertical overflow/drainage end-suction pumps (as well as the display effect pumps) are installed on and penetrate this grating. When excess water raises the lowest pool level, float switches would presumably start one or both of the drainage pumps (depending on demand) in alternating fashion. The drain pump(s), as noted previously in this report, may discharge this water to the storm system, as discharge there was often allowed when the fountain was designed. However, current codes typically demand that all treated fountain water be discharged to the sanitary sewer, through an air gap.

<u>Drainage/Overflow System and the Potential for Equipment Space Flooding</u>

There is an inherent flooding risk associated with the current drainage drainage/overflow management scenario at Peavey Plaza. Specifically, if water entering the lowest pool exceeds the combined pumping capacity of the drain pumps, the plaza can fill fully or partially, and equipment space water level will equalize with the plaza water level and likely flood the room. One could imagine a scenario in which an epic storm hits while one or both of the drain pumps fail, perhaps because of a power outage or an unspecified mechanical or electrical failure. In this scenario equipment space flooding would be extremely likely.

To our knowledge flooding of this sort has happened at least once; although it is not known if the drain pump(s) failed or were simply overwhelmed by the rainfall rate.

The question then becomes: how many flooding events can be tolerated, and at what frequency? In light of this question we then ask: what aggressive (and perhaps costly) measures will The City consider in order to make flooding less likely or virtually impossible? The unpredictable stress of climate change and the threat of more rain make this determination more relevant each year—if, as we were informally told (hearsay?), the last equipment space flood was due to a 500-year storm event, at what point along the arch of climate change will the 500-year event become the new 100-year event--or new 50-year event?

We would note though that flooding could not only damage or ruin gear worth hundreds of thousands of dollars, but if not properly handled, flooding could create a danger to for operating personnel and possibly plaza patrons as live electrical gear became submerged under electrically conductive water.

- **Example 1**: CMS knows of one event in which a subterranean equipment vault flooded in what was probably a hurricane or something like it. In this case, water in the vault rose to the hatch door at grade level. Submerged but energized electrical gear heated the flood water to nearly the boiling point (as discovered by operating personnel when they opened the hatch after the storm). We do not know and don't want to know what would have happened if a well-grounded (electrically speaking) maintenance person would have touched the water before power was turned off.
- **Example 2**: CMS was the water feature consultant of record for the National World War II Memorial in Washington DC. This extremely large fountain is also located in a sunken plaza, just under the Washington Monument, and next to the tidal basin where other memorials exits. During the design process it was acknowledged that at some point the tidal basin and therefore the WWII Memorial would flood—it wasn't a matter of *if*, but rather a matter of *when*. To protect against equipment space flooding, giant flood doors were installed which would prevent water intrusion into what is a huge equipment space when the Memorial flooded. True to predictions, the tidal basin and the WWII Memorial plaza flooded in a great storm shortly after the fountain gear was installed—but the flood doors held and literally millions of dollars of equipment, meant to last 100-years, was saved.

Given the sunken elevation of Peavey Plaza and that of the lowest pool, and given the elevation of the equipment space, "flood-proofing" the existing equipment space is not a trivial design problem, and should be considered by an experienced mechanical or fountain engineer well versed in such issues. That being said, we offer the following preliminary and not necessarily exhaustive comments for consideration and to facilitate the more comprehensive design effort which will surely be advised:

1. Keeping unwanted water out of the equipment space:
    a. A watertight ship's marine door could be installed to keep water from entering the equipment space through that entry point if the plaza flooded.
    b. All ventilation inlets and outlets would need to daylight above the 500 year plaza flood plain—i.e., well above street flood level. We don't want water to get in through the vents.
    c. The drainage pumps could be separately provided with emergency power if available.
    d. This subsection starts with a question: How can water be kept from entering the equipment space through the passage from lowest pool outside to the area beneath the grate as the plaza water level rises? One possible way would be to reconfigure the passage between the lower pool and the equipment space so that a robust wall or external plate separates the two regions—a barrier which is penetrated by some number of equalization pipes or perhaps one large pipe, which is/are large enough to passively handle the inflow of water back into the wetwell when the effect pumps are in normal operation.
        i. These pipe(s) would be equipped with <u>submersible</u> bronze or stainless steel *pneumatically actuated* butterfly valves on the equipment room side of the penetration.
        ii. These valves would be "fail safe" in that they would be configured to close in the event of a power outage, preventing water from entering the space from the outside. A reservoir of compressed air would close the valve, even in the event of a power failure.
        iii. The "pool side" of the pipes would need to be appropriately screened and possibly split, so that un-vented higher pressure on the pool side could not pin a swimmer to the inlet and possibly result in drowning.
        iv. A high water float switch in the equipment space would trip if water rose above the grating (trip point lower than any live electrical parts) for any reason and started to flood the room. Tripping this switch would also cause:
            1. The pneumatic valve(s) to close, preventing more water from entering the equipment space from the fountain.
            2. All fountain display effect and filter pumps would be de-energized. Water addition by the auto makeup system would be blocked.
            3. Appropriate alarms would be sounded or transmitted to operating personnel, alerting them to the situation.
            4. As noted above, the valve(s) would also pneumatically close upon power loss.
    e. It must be insured that all possible sources of water intrusion (e.g., open conduits) are sealed so that water cannot get in by unanticipated means.
    f. Powering the drain pumps through a separate, emergency power source might be considered, so that they function even in a power outage. This may not be practical, and would probably be quite costly, but is worth considering.
    g. Feeding power into the room through a float switch actuated shunt-trip breaker on the feeder outside the room should be considered. A shunt trip breaker will accept an external

contract closure from, for instance, a float switch in the equipment space. When the contact closes, the shunt-trip feature activates and causes the circuit breaker to open. In our case the room would be de-energized. This is for personnel as well as equipment protection.

i. The shunt-trip activating float switch would be set to trip below any live electrical parts.

ii. In this scenario, the drainage pumps would also be de-energized.

iii. It might also be possible to replace the vertical drain pumps (which have vulnerable-to-flooding motors) with submersible pumps which provide equivalent performance capabilities. If submersible disconnect switches can be provided (disconnects are required by code), the now fully submersible drainage pumps could be fed from a separate power source which is not de-energized by the shunt trip feeder breaker.

h. The project structural engineer would need to be fully involved in this portion of the project. Specifically s/he must note that if the plaza flooded but the equipment space did not, there would be added hydrostatic pressure from the outside, which would be exerted on the equipment space walls. The structural engineer would verify that the room could withstand whatever pressure occurred during this unusual event.

We must stress that the above discussion regarding equipment space flood prevention is not meant to be exhaustive or definitive. Rather it is meant to foster further discussion and investigation by the design team in conjunction with The City. This is a complex problem which requires careful and thorough analysis, and exhaustive vetting by all design team members before a solution is agreed upon and implemented.

FOUNTAIN DISCHARGE – SANITARY SEWER ROUTING REQUIREMENTS

As has been noted before in this report, current codes require that all fountain discharge of chemically treated water be routed to the sanitary sewer via an air-gap to prevent cross contamination. For a new fountain, this would include drainage, overflow, and backwash effluent. While the historical drawings suggest that backwash discharge was routed to the sanitary (through an air-gap?), it is not clear if the drainage pump discharge is being routed to sanitary or storm—and both effluent destinations were common in the 1970s. If the drainage discharge (non-backwash) was routed to storm, it is possible that this configuration can be “grandfathered” in for the renovation; however we felt it important to note how new fountains are handled, as this might apply to fountains in Minneapolis as well.

EXCESSIVE FOUNTAIN WATER USAGE

It was reported by site personnel that the fountain used water excessively, for reasons which had yet to be determined. We were further informed that to the knowledge of current site personnel, no obvious places where water was leaking (e.g., soggy ground, bubbling up of fountain water). We would note first that a fountain such as this, with a high degree of aeration (enhances evaporation) and misting would be expected to go through a fair amount of water by these means—unfortunately due to the size highly unique nature of the Peavey display, this would be a hard thing to quantify. That being said, it is still possible to look into some possible cause and potential “fixes” for unexpected and unwanted water loss.

Structural leakage:

We were told that there are a number of possible structural failures which could cause leakage. For instance, there is a large crack in the reflecting pool from which water possibly could leak. There are also central drain fittings in the floor of this quite large pool out of which water might leak (either at the fitting or along the associated fitting’s piping run back to the lowest pool. One way to test this is hypothesis would be to fill only the lower pool and then let it sit for a couple of days when there is no precipitation and see what happens. Be sure that any float actuated (demand based) water addition systems are disabled for this test. If the level falls at a rate significantly greater than the local pan evaporation rate, a leak must be suspected.

Pump Check valve failure

This would cause pool(s) and piping downstream of the check valve to drain back through the affected pump and into the lowest/pool wetwell when the pump stops. Water would therefore build up in the lowest pool/wetwell. If this condition was severe, water could be lost through the fountain's overflow system.

This hypothesis and possible contributing factor may be able to be tested by closing isolation valve(s) on the line(s) downstream of the check valve and seeing what (if any) pools stop draining when the pump is stopped and the isolation valve is closed. During all facets of the test, note and write down which pool or pools empty.

This test presupposes a full understanding of the plumbing schematic (which is to be prepared), which under scrutiny should reveal which pools would be expected to drain under normal conditions when the fountain is turned off, as compared to which pools drain (or don't drain) unexpectedly under conditions of this test.

Water level drawdown during startup and consequent over-addition of makeup water:

This potential mode of water loss requires a bit of explanation, and ultimately pertains to level sensor settings:

As we recall, site personnel stated that there was once an auto water makeup system (the remnants of which appear to be still visible in the form of an abandoned water supply valve) which, when functioning, added water on demand—with the demand actuation level being that at which the auto makeup "on" sensor or float is set.

Note that:

1. When the fountain is off, all the water that is in circulation when the fountain is on will drain to the lowest body of water.
2. Note also that that when the weir pumps start, the lowest pool/wetwell level draws down to reflect the water now being placed in circulation—water which resides in the lowest pool when the fountain is off.
3. Given the above, the auto make-up float (or whatever type of level sensor was used when the fountain was decommissioned) must be calibrated to add water if the lowest pool level falls below the stabilized "operating level," but not sooner. The "operating level" is that which obtains when the lowest pool drawdown has stopped falling because the amount of circulating water (which was in the lowest pool) has reached its equilibrium point--flow out from the lowest pool equals flow back into it.
    a. Note that the amount of water in circulation is directly proportion to flowrate through the display:

       More flow = more water in circulation = more operational drawdown.
4. It follows from the above that if the auto make-up system is set to actuate too soon (i.e. before the lowest pool stops drawing down), and therefore tries to maintain a water level higher than that of the stabilized "operating level," extra water will be added to the system as the lowest pool continues to draw down, because the make-up system switched on prematurely. As the lowest pool level continues to fall to its operating level, the auto makeup system will keep adding water until its makeup function is satisfied.

5. It is then possible that when the fountain is subsequently switched off and circulating water returns to the lowest pool with its now too high water level, the extra added water will rise above the overflow system's setpoint and be dumped to waste by the drain pump(s), which only then sensed the extra water.
6. Bottom line:
    a. The make-up and overflow system floats must be set relative to eachother, so that they trip at elevations which do not produce water waste.

Lowest Pool/wetwell sizing

It must also be verified that lowest pool/wetwell was and is adequately sized, so that it holds a water volume sufficient to operate the fountain.

In other words:

- All the water that circulates throughout the fountain resides in the lowest pool when the fountain is off. When the fountain starts and flow builds up, the lowest pool level draws down to supply the circulating water and ultimately stabilizes at its operating level. It follows that:
- There must be sufficient storage capacity in the lowest pool (reservoir), so that when the fountain starts and pulls water from the lowest pool, the lowest pool level doesn't fall excessively and signal the auto makeup system to add extra water, or cause the pumps to entrain air.

CMS has no reason to believe that the lowest pool was not properly sized at this point—but this would be one of the things to revisit as part of the renovation process. One possible result of under sizing could be excessive water loss through the mechanisms described above.

Pressure pipe leakage:

It is also possible that water is being lost through the pressure piping (downstream of the pump) when the fountain is in operation. As stated previously, the pump discharge piping (as well as all other piping) must be pressure tested and inspected by other means (e.g. video, radio transmission etc.) for possible leakage.

GOOD FOUNTAIN MAINTENANCE AND THE IMPORTANCE OF IT

Our final thoughts will pertain to fountain maintenance. The Peavey fountain will, by its sheer size, require a fair amount of attention. We are herein suggesting modernization and the addition of automation which will not only assist in maintenance (reduce person-hours), but will help keep the fountain viable well into the 21st century.

If the fountain gear is modernized and automated, it should be relatively self-maintaining when compared to the old water feature—*relatively* because the gear must still be inspected and maintained and occasionally repaired. The fountain cannot be a "fire it and forget it" system.

If the new gear is well maintained, the most labor intensive aspect of fountain maintenance will likely be keeping it clean and looking good. The amount of time this takes will fluctuate with the seasons; spring and autumn will take the most time because of falling leaves, flower petals, pollen, and so forth. Although the current fountain mechanical system has a built-in vacuum system, which may or may not have ever worked well (query operating personnel in this regard), we suggest the City purchase a large capacity portable vacuum cart with an integral high capacity cartridge filter. These come as gas or electric powered units, and one manufacturer is Maxi-Sweep (maxisweep.com; 1.970.858.7266). These units are typically used to clean Olympic size swimming pools, municipal plunges, etc., and can be purchased with very large, multi-ported vacuum heads (3 or 4 feet wide), which greatly shorten vacuuming time.

Finally, we believe that fountain maintenance is most successful when one or two maintenance persons become "responsible for the fountain." The fountain becomes their charge (and hopefully a point of pride), and they are given the time and resources to understand "how the fountain works," its finer points, idiosyncrasies, and so forth. Water maintenance, and even pool cleaning can be contracted out if need be—but the professionals doing this work must be experienced and competent, and *care about the fountain.*

No fountain will be successful in the long run without good maintenance, and the City should support this notion by first anticipating and understanding it, and then insuring that proper funds are set aside for ongoing maintenance. This should certainly be discussed with the various government and philanthropic funding sources.

--end of report--